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ABSTRACT

Three concerns investigated were: (1) the effect of two methods of teaching reading comprehension skills in a content area upon students' problem-solving performance on first-year algebra word problems; (2) the effects of three achievement levels of each assigned factor--reading comprehension, computational mathematics, and mathematical reasoning--upon students' problem-solving performance; and (3) overall mean gain scores in reading comprehension achievement by two treatment groups. Scores from 115 students who took the Algebra I Word Problem Test were analyzed. Overall mean gain scores from pretest, and posttest administration of the California Achievement Test: Reading Comprehension Subtest were analyzed. Results indicated that students using the Reading Guide Method outperformed students using the Directed Reading Method in problem solving performance. The problem solving performance of students in the above-average achievement level for mathematical reasoning was significantly greater than those in the below-average level. For above-average and average students in reading comprehension the Reading Guide Method was more effective; for below-average, the Directed Reading Method was more effective. (Author/YP)

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The Effects of Two Reading Methods in a Content Area Upon Ninth-grade, First-year Algebra Students' Problem-solving Performance of Algebra Word Problems and Reading Achievement

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The Effects of Two Reading Methods in a Content Area Upon Ninth-grade, First-year Algebra Students' Problem-solving Performance of Algebra Word Problems and Reading Achievement

The purpose of the study was to investigate three concerns: (1) the effect of two methods of teaching reading comprehension skills in a content area upon students' problem-solving performance of first-year algebra word problems; 92) the effects of three achievement levels of each assigned factor--reading comprehension, computational mathematics, and mathematical reasoning--upon students' problem-solving performance; and (3) overall mean gain scores in reading comprehension achievement by two treatment groups. Scores from 115 students who took the algebra I word problem Test in December, 1989, were analyzed. Overall mean gain scores from pretest, posttest administration of the California Achievement Test: Reading Comprehension Subtest were analyzed. Results indicated that students in the Reading Group Method group outperformed students in the Directed Reading Method in problem-solving performance. The problem-solving performance of students in the above-average achievement level for mathematical reasoning was significantly greater than those in the below-average level. For above-average and average students in reading comprehension the Reading Guide Method was more effective; for below-average, the Directed Reading Method was more effective.

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International and national studies have reported the mathematical performance of students in the United States to be well below that of students in countries competitive with the United States in business, science, and technology. The need for increased proficiency in problem-solving skills and students' continued difficulty in solving word problems, has claimed attention from educators and researchers alike (Berger, 1984). Significant gains have been reported in problem-solving ability when specified methods of reading instruction were implemented in elementary mathematics programs. From reviewing the literature few studies have been reported regarding students' problem-solving performance of algebra word problems when specified methods of reading instruction were incorporated in the algebra program.

The Problem

Students' success in solving first-year algebra word problems may be dependent on the method of teaching reading comprehension skills in a content area and students' achievement levels in reading comprehension, computational mathematics, and mathematical reasoning. The purpose of the study was to investigate three concerns: (1) the effect of two methods of teaching reading comprehension skills in a content area--the Directed Reading Method and the Reading Guide Method--on students' problem-solving performance; (2) the effects of three achievement levels--above-average, average, and below-average--of each assigned factor--reading comprehension, computational

mathematics, and mathematical reasoning on students' problem-solving performance; and the differential effects between the two methods of teaching reading comprehension skills in a content area and the three achievement levels of each assigned factor upon students'problem-solving performance; and (3) the overall mean gain scores in reading comprehension achievement of the two treatment groups.

The study was a pretest, posttest, quasi-experimental design with intact, nonequivalent comparison groups. One hundred fifteen scores obtained from the Algebra I Word Problem Test were analyzed for the first concern. For the second concern 115 scores on the Algebra I Word Problem Test were used in determining the effect of achievement levels of reading comprehension and the differential effects of achievement levels of reading comprehension and two reading methods on problem-solving performance. For the remainder of the second concern 120 scores were analyzed. For the third concern gain scores of 170 students were determined by the California Achievement Test, Form F, Reading Comprehension Subtest.

The first concern of the study was to determine the effect that the Directed Reading Method (DRM) and the Reading Guide Method (RGM) had on ninth-grade, first-year algebra students' problem-solving performance of first-year algebra word problems. To accomplish that, the answer to the following question was sought:

1. What significant difference in overall mean scores on

the Algebra I Word Problem Test (AWPT) existed between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taugth reading comprehension skills in a content area using the Reading Guide Method?

To answer question 1, two-way analysis of covariance with an F' evaluated the significance of the variance of the two treatment groups as column main-effects using the scores on the Algebra I Word Problem Test. Raw scores on the CAT Mathematics Concepts and Applications Subtest, were used as the covariant.

The second concern of the study was to investigate the effects of three achievement levels--above-average, average, and below-average--of each assigned factor--reading comprehension, computational mathematics, and mathematical reasoning--on ninth-grade, first-year algebra students' problem-solving performance of first-year algebra problems; and, further, to investigate differential effects between the two methods of teaching reading comprehension skills in a content area--DRM and RGM--and three achievement levels of each assigned factor. To accomplish that concern, answers to the following questions were sought:

2. What significant difference in overall mean scores on the Algebra I Word Problem Test (AWPT) existed among ninth-grade, first-year algebra students assigned to achievement levels of above-average, average, and below-average for reading comprehension?

3. What significant interaction in overall mean scores on the Algebra I Word Problem Test (AWPT) exists between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-average, average, and below-average for reading comprehension?

4. What significant difference in overall mean scores on the Algebra I Word Problem Test (AWPT) exists among ninth-grade, first-year algebra students assigned to achievement levels of above-average, average, and below-average for computational mathematics?

5. What significant interaction in overall mean scores on the Algebra I Word Problem Test (AWPT) exists between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-average, average, and below-average for computational mathematics?

6. What significant difference in overall mean scores on the Algebra I Word Problem Test (AWPT) exists among ninth-grade, first-year algebra students assigned to achievement levels of above-average, average, and below-average for mathematical reasoning?

7. What significant interaction in overall mean scores on the Algebra I Word Problem Test (AWPT) exists between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-average, average, and below-average for mathematical reasoning?

To answer questions 2, 3, 4, 5, 6, and 7, two-way analysis of covariance with an F' test analyzed the scores on the Algebra I Word Problem Test. For questions 2, 3, 4, and 5 raw scores on the CAT Mathematics Concepts and Applications Subtest were used as the covariant. For questions 6 and 7 raw scores on the CAT Mathematics Computation Subtest were used as the covariant. To answer question 6, the Scheffe' test was utilized in comparing the adjusted means of the three achievement levels for mathematical reasoning to determine which levels were significantly different.

The third concern of the study was to determine the overall mean gain scores of reading comprehension achievement of students taught reading comprehension skills in a content area by either the Directed Reading Method or the Reading Guide Method. To accomplish that concern, the answer to the following question was sought:

8. What significant difference in overall mean gain scores in reading comprehension achievement on the California

Achievement Test, Form F, Reading Comprehension Subtest, existed between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method?

To answer question 8, a t-test for independent samples was utilized in evaluating the mean gain scores of Treatment Group 1 (DRM) and Treatment Group 2 (RGM) on the California Achievement Test, Form F, Reading Comprehension Subtest.

The hypothesis-testing element of the study analyzed problem-solving performance and reading comprehension achievement by exploring the following hypotheses:

1. A significant difference in the overall mean scores on the Algebra I Word Problem Test (AWPT) exists between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method.

2. A significant difference in the overall mean scores on the Algebra I Word Problem Test (AWPT) exists among ninth-grade, first-year algebra students assigned to achievement levels of above-average, average, and below-average for reading comprehension.

3. A significant interaction in overall mean scores on the

Algebra I Word Problem Test (AWPT) exists between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-average, average, and below-average for reading comprehension.

4. A significant difference in the overall mean scores on the Algebra I Word Problem Test (AWPT) exists among ninth-grade, first-year algebra students assigned to achievement levels of above-average, average, and below-average for computational mathematics.

5. A significant interaction in overall mean scores on the Algebra I Word Problem Test (AWPT) exists between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-average, average, and below-average for computational mathematics.

6. A significant difference in the overall mean scores on the Algebra I Word Problem Test (AWPT) exists among ninth-grade, first-year algebra students assigned to achievement levels of above-average, average, and below-average for mathematical reasoning.

7. A significant interaction in overall mean scores on the

Algebra I Word Problem Test (AWPT) exists between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-average, average, and below-average for mathematical reasoning.

8. A significant difference in overall mean gain scores in reading comprehension achievement on the California Achievement Test, Form F, Reading Comprehension Subtest exists between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method.

Description of Procedure

The field experiment was conducted during the first twelve weeks of the 1988-1989 school year. Due to the importance of external validity and to the inability to assign students to treatment groups, the design of the study was a pretest, posttest quasi-experimental design with intact, nonequivalent comparison groups. The dependent variables in the study were problem-solving performance of first-year algebra word problems as measured by the Algebra I Word Problem Test (AWPT) and reading achievement gain scores as measured by the California Achievement Test (CAT), Form F, Reading Comprehension Subtest. The

independent variables were the instructional methods--the Directed Reading Method (DRM) and the Reading Guide Method (RGM). Other independent variables in the study were the following assigned factors: reading comprehension, computational mathematics, and mathematics reasoning abilities.

Students' pretest scores obtained from the CAT, Form F, Reading Comprehension Subtest, Mathematics Computation Subtest, and Mathematics Concepts and Applications Subtest determined the achievement levels of above-average, average, and below-average for each assigned factor, respectively. Students whose subtest scores fell within the boundaries defined by subtracting one-half standard error of measure from one-half standard deviations above and below the mean score were assigned to the average achievement level. Students in the above-average group were determined to be those whose scores were above the boundary defined by one-half standard deviation above the mean. Those assigned to the below-average group were determined to be those whose scores were below the boundary defined by one-half standard deviation below the mean.

When groups are heterogeneous, use of the F test is invalid (Huck, 1974). The F_{max} test is a procedure for testing the assumption of equal variances (Huck, 1974). The F_{max} test was used on the pretest scores of the CAT, Mathematics Concepts and Applications Subtest, which is an appropriate covariate, to determine if the variance between the treatment groups--Directed Reading Method and Reading Guide Method--was the same. The

computation of the F_{max} test produced the largest mean square of 72.57 and the smallest mean square of 50.43. This produced an F_{max} value of 1.44 with 82/86 degrees of freedom, which was significant at the .01 level.

Since the variance was determined to be heterogeneous, the raw scores obtained from the Algebra I Word Problem Test (AWPT) were subjected to two-way analysis of covariance using an adjusted F test. Raw scores on the CAT, Mathematics Concepts and Applications Subtest were used as a covariant when achievement levels for reading comprehension and computational mathematics were investigated, while raw scores on the CAT, Mathematics Computation Subtest were used as a covariant when achievement levels for mathematical reasoning were investigated. The means, adjusted means, standard deviations, and adjusted standard deviations were computed for treatment groups and for achievement levels--above-average, average, and below-average--for reading comprehension, computational mathematics, and mathematical reasoning. The t-test for independent samples was employed to analyze the overall mean gain scores in reading comprehension achievement between the treatment groups--DRM and RGM.

The universe of the study included all ninth-grade, first-year algebra students in a parish of Northwest Louisiana during the 1988-1989 school year. The population selected for the study were those ninth-grade, first-year algebra students who were enrolled in first-year algebra for the first time and who were between the ages of thirteen years six months and fourteen years

eight months. The sample was further limited by the exclusions of those students enrolled in classes of the nonparticipating teacher; those academically-gifted students who pursued first-year algebra for a Carnegie unit during their eighth-grade year; and those students in the sample who absence exceeded five days.

Five teachers from the three participating high schools were randomly assigned to one of the two methods of teaching reading comprehension skills in a content area--DRM or RGM. Assignments were based on student enrollment and on assignment of equal or approximately equal numbers of students to each method of instruction. The methods for teaching reading comprehension skills in a content area, DRM and RGM, were implemented during the first twelve weeks of the 1988-1989 school year.

To insure consistency in the execution of teaching the two methods of reading comprehension skills, three measures were taken: (a) lesson plans were prepared for participating teachers; (b) observations were made by principals in participating schools; and (c) inservice meetings were conducted for participating teachers and principals. First, lesson plans were designed for teaching the DRM or RGM relative to solving word problems in the first four units of first-year algebra. The word problem lessons were taught in the sequence introduced in the Algebra Structure and Method Book 1 by Dolciani and others (1979) and in accordance with the Parish Guide and its time-lines.

Second, principals in the participating schools observed

classes during the twelve-week treatment period. Third, participating teachers were inserviced regarding the procedure used for the assigned method of instruction. Principals were instructed in the proper use of the observation checklist.

The Algebra I Word Problem Test was specifically designed for this research. The test measures students' problem-solving performance of first-year algebra word problems and is designed for students enrolled in a first-year algebra course. This test consists of 25 multiple-choice items and requires approximately 50 minutes to complete. The AWPT can be hand scored or computer scored. The AWPT was developed by identifying objectives of the course content as specified in the course syllabus.

The content validity of the Algebra I Word Problem Test was established via the Delphi Technique. To accomplish this, a panel of five experts was selected to evaluate the objectives and test items. The five experts selected to serve on the panel have expertise in the field of mathematics and/or statistics. Each panel member holds a university degree in mathematics or a related field.

The panel members were given copies of five objectives and were instructed to rate each objective for its appropriateness as a test objective. After the five objectives were rated as appropriate for the test, test items for each of the objectives were written. These test items were then rated for appropriateness and level of difficulty by the panel members. From those test items rated as appropriate, a selection of test

items representative of the varying levels of difficulty--easy, average, and difficult--were chosen for the test. A copy of the Algebra I Word Problem Test was then reviewed by each panel member for necessary final revisions. The Kuder-Richardson Estimate of Reliability using split-halves technique rendered a reliability coefficient of 0.769 for the Algebra I Word Problem Test. A reliability coefficient of 0.70 or higher indicates that the test is reliably and accurately measuring the characteristics for which it is intended (Bruning, 1968).

The California Achievement Test, Form F, Reading Comprehension Subtest is a paper-and-pencil, multiple item test of 50 minutes designed for administration to students in grades nine to twelve. The test is scored by hand or computer. According to the CAT Technical Report (1987), the reliability coefficient of the California Achievement Test, Form F, ranged from .86 to .96 using the Kuder-Richardson Formula 20. Content validity depends upon whether or not the items in a specific test accurately represent the subject matter that the test is designed to cover. The content of the California Achievement Test, Form F is compatible with current state and parish curriculum guides and instructional programs.

Presentation and Analysis of Data

Two hundred sixty-seven ninth-grade students completed the three subtests of the California Achievement Test, Form F, and the Algebra I Word Problem Test. Ninety-seven students or 36.3% of the participants did not fit the criteria of a ninth-grade,

first-year algebra student and were dropped from the study. One hundred seventy students were candidates for selection for the study. These statistics are reported in Table 1.

Table 1

Number and Percentage of Subjects for Study

Group	N	Percentage
Eligible Subjects	170	43.7
Ineligible Subjects	97	36.3
Total	267	100.0

The presentation and analysis of data collected for the investigation was organized in the following manner: (1) Effect of Method of Teaching Reading on Mathematics Problem-solving Performance; (2) Effects of Achievement Levels of Assigned Factors and Differential Effects Between Methods of Teaching Reading and Achievement Levels on Mathematics Problem-solving Performance; and (3) Difference of Mean Gain Scores in Reading Comprehension Between Methods of Teaching Reading.

Effect of Method of Teaching Reading on Mathematics Problem-solving Performance

The first null hypothesis provided a determination of the overall main-effects of two methods of teaching reading comprehension skills in a content area, DRM and RGM, upon students' problem-solving performance of first-year algebra word problems.

Null Hypothesis 1

Null Hypothesis 1 stated that no significant difference in overall mean scores on the Algebra I Word Problem Test (AWPT) existed between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method. Of the 170 eligible participants, data from 115 subjects were used with 50 subjects randomly selected out of the sample. Subjects receiving instruction for reading comprehension in a content area by the DRM totaled 60 or 52.17 % of the sample while subjects receiving instruction for reading comprehension in a content area by the RGM totaled 55 or 47.83%. Table 2 reports these statistics.

Table 2

Number and Percentage of Subjects in Treatment Group 1 and Treatment Group 2

Group	N	Percentage
Treatment Group 1 (Directed Reading Method)	60	52.17
Treatment Group 2 (Reading Guide Method)	55	47.83
Total	115	100.00

The 60 subjects in Treatment Group 1 (DRM) had a mean score of 11.43 and a standard deviation of 3.66 on the Algebra I Word Problem Test while the 55 subjects in Treatment Group 2 (RGM) had a mean score of 12.49 and a standard deviation of 3.39. The total mean score of the sample was 11.94 and the standard deviation was 3.56 on the AWPT. Treatment Group 1 (DRM) had an adjusted mean of 11.29 with an adjusted standard deviation of 3.41, while Treatment Group 2 (RGM) had an adjusted mean of 12.48 with an adjusted standard deviation of 3.10. The adjusted total mean for the 115 subjects was 11.88 with an adjusted standard deviation of 3.32. These statistics are reported in Table 3.

Table 3

Means, Standard Deviations, Adjusted Means, and Adjusted Standard Deviations for Subjects Receiving Instruction in Directed Reading Method and Reading Guide Method

Group	N	$\bar{X}$	SD	$\bar{X}$	SD
Treatment Group 1 (Directed Reading Method)	60	11.43	3.66	11.29	3.41
Treatment Group 2 (Reading Guide Method)	55	12.49	3.39	12.48	3.10
Total	115	11.94	3.56	11.88	3.32

A two-way analysis of covariance with an F' test evaluated the significance of the variance between Treatment Group 1 (DRM) and Treatment Group 2 (RGM) as column main-effects. Table 4 displays the between groups adjusted sum of squares and adjusted mean square with 1 degree of freedom for treatments as 42.304 for both. The adjusted error sum of squares was 1122.300 with an adjusted mean square of 10.392 and 108 degrees of freedom. The total adjusted sum of squares was 1247.300 with 113 degrees of freedom. The calculated F' value was 4.07 and was found to be significant at the 0.0436 level. The critical value to find significance at the 0.05 level with 1/108 df was 3.92.

Table 4

Summary of Analysis of Covariance of Comparing Adjusted Means for Treatment Groups, using Mathematical Reasoning as a Covariant; Comparing Adjusted Means of Three Achievement Levels for Reading Comprehension; Comparing Adjusted Means for Interaction of Treatments and Levels

Source	df	SS'	MS'	F'	P
Treatments (DRM & RGM)	1	42.304	42.304	4.07*	0.0436
Levels (Reading Comprehension Ability)	2	0.985	4.923	0.05**	0.9431
Interaction (Treatments X Levels)	2	81.749	40.875	3.93**	0.0220
Error	108	1122.300	10.392		
Total	113	1247.300			

*F' required for significance with 1/108 df is 3.92
**F' required for significance with 2/108 df is 3.07

Null Hypothesis 1 was rejected. A significant difference does exist in problem-solving performance between ninth-grade, first-year algebra students taught reading comprehension in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method. Students taught reading comprehension in a content area using the Reading Guide Method out performed students taught reading comprehension

in a content area using the Directed Reading Method in solving first-year algebra word problems.

Effects of Achievement Levels of Assigned Factors and Differential Effects Between Methods of Teaching Reading and Achievement Levels on Mathematics Problem-solving Performance

Null Hypotheses 2, 3, 4, 5, 6, and 7 investigated the effects and interaction between two methods of teaching reading comprehension skills in a content area, the Directed Reading Method and the Reading Guide Method, upon students' problem-solving performance of first-year algebra word problems when grouped into above-average, average, and below-average levels for each of the assigned factors--reading comprehension, computational mathematics, and mathematical reasoning. Of the 170 subjects that were candidates for selection for the analysis for Null Hypotheses 2 and 3, 115 subjects were used with 55 subjects randomly selected out of the sample.

Null Hypothesis 2. Null Hypothesis 2 stated that no significant difference in overall mean scores on the Algebra I Word Problem Test existed among ninth-grade, first-year algebra students assigned to achievement levels of above-average, average, and below-average for reading comprehension. Forty subjects were assigned to the above-average and average achievement levels for reading comprehension; each level represented 34.78% of the sample. Thirty-five subjects or 30.44% were assigned to the below-average achievement level for reading

comprehension. Table 5 reports this information.

Table 5

Number and Percentage of Subjects Assigned to Achievement Levels for Reading Comprehension for Evaluation of Null Hypothesis 2

Group	N	Percentage
Above-average	40	34.78
Average	40	34.78
Below-average	35	30.44
Total	115	100.00

The 40 subjects in the above-average achievement level for reading comprehension had a mean score of 12.53 with a standard deviation of 3.40 for problem-solving performance on the Algebra I Word Problem Test. The 40 subjects assigned to the average achievement level for reading comprehension had a mean score of 11.73 with a standard deviation of 3.52, while the 35 subjects assigned to the below-average achievement level reported a mean score of 11.51 with a standard deviation of 3.78. The adjusted mean scores for the above-average, average, and below-average achievement levels for reading comprehension were 11.76, 11.90 and 11.98, respectively; the adjusted standard deviations for these achievement levels were reported as 3.24, 3.06, and 3.72,

respectively. These statistics are reported in Table 6.

Table 6

Means, Standard Deviations, Adjusted Means, and Adjusted Standard Deviations for Subjects Grouped by Achievement Levels for Reading Comprehension

Group	N	$\bar{X}$	SD	$\bar{X}$	SD
Achievement Levels					
Above-average	40	12.53	3.40	11.76	3.24
Average	40	11.73	3.52	11.90	3.06
Below-average	35	11.51	3.78	11.98	3.72

A two-way analysis of covariance with an F' test evaluated the significance of variance of the row main-effects among the three achievement levels--above-average, average, and below-average--for reading comprehension upon students' problem solving performance of first-year, algebra word problems. Table 4 (page 14) displays the between groups adjusted sum of squares and adjusted mean square with 2 degrees of freedom for achievement levels for reading comprehension as 0.985 and 4.923, respectively. The adjusted error sum of squares was 1122.300 with an adjusted mean square of 10.392 and 108 degrees of freedom. The total adjusted sum of squares was 1247.300 with 113 degrees of freedom. The calculated F' value was 0.05. The

critical value on the Algebra I Word Problem Test existed between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-aveage for reading comprehension.

Null Hypothesis 3

Null Hypothesis 3 stated that no significant interaction in the overall mean scores on the Algebra I Word Problem Test existed between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-average, average, and below-average for reading comprehension.

Null Hypothesis 3 evaluated the interaction between two methods of teaching reading comprehension skills--DRM and RGM--in a content area and three achievement levels--above-average, average, and below-average--for reading comprehension ability upon students' problem-solving performance on the AWPT, using two-way analysis of covariance with mathematical reasoning as a covariant. One hundred seventy subjects were candidates for selection for the analysis of Null Hypothesis 3. Twenty-three subjects or 13.53% were assigned to the above-average achievement

level for reading comprehension for Treatment Group 1 (DRM). Twenty-one subjects or 12.35% were assigned to average achievement level for Treatment Group 1 (DRM), while 35 subjects or 20.59% were assigned to below-average achievement level for Treatment Group 1 (DRM). Eight subjects or 4.71% in Treatment Group 1 (DRM) were dropped from the study; their scores on the Algebra I Word Problem Test did not meet the criteria for assignment to any of the three achievement levels. Thirty-three subjects or 19.41% were assigned to the above-average achievement level for Treatment Group 2 (RGM). Twenty-seven subjects or 15.88% were assigned to the average achievement level for reading comprehension for Treatment Group 2 (RGM), while 15 subjects or 8.82% were assigned to the below-average achievement level for Treatment Group 2 (RGM). Eight subjects or 4.71% in Treatment Group 2 were dropped from the study since their scores did not meet the criteria for assignment to an achievement level. This is reported in Table 7.

Table 7

Number and Percentage of Subjects Grouped According to Treatment and Achievement Level for Reading Comprehension for Null Hypothesis 3 Prior to Random Selection

Group	N	Percentage
Treatment 1 (DRM)		
Above-average	23	13.53
Average	21	12.35
Below-Average	35	20.59
Dropped	8	4.71
Treatment 2 (RGM)		
Above-average	33	19.41
Average	27	15.88
Below-average	15	8.82
Dropped	8	4.71
Total	170	100.00

After dropping 16 subjects who did not meet the criteria for assignment to achievement levels for reading comprehension, 115 subjects were used for evaluating Null Hypothesis 3. Twenty subjects were assigned to the above-average Treatment Group 1 (DRM), comprising 17.39% of the sample of 115. Average Treatment Group 1 (DRM) subjects totaled 20 or 17.39%. Below-average

Treatment Group 1 (DRM) subjects totaled 20 or 17.39%. The above-average Treatment Group 2 (RGM) subjects totaled 20 or 17.39%. Average Treatment Group 2 (RGM) subjects totaled 20 or 17.39% while below-average Treatment Group 2 (RGM) subjects totaled 15 or 13.05%. This information is reported in Table 8.

Table 8

Number and Percentage of Subjects Selected for Evaluation of Null Hypothesis 3

Group	N	Percentage
Treatment 1 (DRM)		
Above-average	20	17.39
Average	20	17.39
Below-average	20	17.39
Treatment 2 (RGM)		
Above-average	20	17.39
Average	20	17.39
Below-average	15	13.05
Total	115	100.00

Above-average Treatment Group 1 (DRM) had a mean score of 11.70 with a standard deviation of 2.96; the average Treatment Group 1 (DRM), a mean score of 10.40 with a standard deviation of 3.38; and the below-average Treatment Group 1 (DRM), a mean score

of 12.20 with a standard deviation of 4.43. Above-average Treatment Group 2 (RGM) had a mean score of 13.35 with a standard deviation fo 3.69; average Treatment Group 2 (RGM), a mean score of 13.05 with a standard deviation of 3.20; and below-average Treatment Group 2 (RGM) a mean score of 10.60 with a standard deviation of 2.56. The total mean score was 11.94 with a standard deviation of 3.56. The above-average Treatment Grup 1 (DRM) had an adjusted mean score of 10.82 with adjusted standard deviation of 2.96. The average Treatment Group 1 (DRM) had an adjusted mean of 10.52 2ith an adjusted standard deviation of 2.65. The below-average Treatment Group 1 (DRM) had an adjusted mean of 12.53 with an adjusted standard deviation of 4.22. The above-average Treatment Group 2 (RGM) had an adjusted mean of 12.71 with an adjusted standard deviation of 3.31. The average Treatment Grojp 2 (RGM) reported a mean of 13.29 with an adjusted standard deviation of 2.86. The below-average Treatment Group 2 (RGM) had an adjusted mean of 11.44 with an adjusted standard deviation of 2.93. The total adjusted mean score was 11.88 with an adjusted standard deviation of 3.32. This information is reported in Table 9.

Table 9

Means, Standard Deviations, Adjusted Means, and Adjusted Standard Deviations for Subjects Grouped By Treatment and Achievement Level for Reading Comprehension

Group	N	$\bar{X}$	SD	$\bar{X}$	SD
Treatment 1 (DRM)					
Above-average	20	11.70	2.96	10.82	2.96
Average	20	10.40	3.38	10.52	2.65
Below-average	20	12.20	4.43	12.53	4.22
Treatment 2 (RGM)					
Above-average	20	13.35	3.69	12.71	3.31
Average	20	13.05	3.20	13.29	2.86
Below-average	115	11.94	3.56	11.88	3.32

A summary of the two-way analysis of covariance comparing adjusted mean scores of the six groups is reported in Table 4 (page 18). The adjusted interaction sum of squares and adjusted interaction mean square with 2 degrees of freedom were 81.749 and 40.875, respectively. The adjusted error sum of squares was 1122.300 with 108 degrees of freedom; the adjusted error mean square was 10.392. The total adjusted sum of squares was 1247.300 with 113 degrees of freedom.

The adjusted F' value was calculated to be 3.93, significant

at the 0.022 level. The critical value of the 0.05 level of significance for 2/108 df is 3.07. Nu711 Hypothesis 3 was rejected. A significant interaction in the overall mean scores on the AWPT existed between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, firsty-ear algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-average, average, and below-average for reading comprehension. The disordinal interaction indicated that Treatment 2, the Reading Guide Method was better for above-average and average students when grouped by achievement levels for reading comprehension and that Treatment 1, the Directed Reading Method was better fo below-average students. To better interpret the results from Table (4 Page 18), a graphical presentation of the interactive effects is shown in Figure 1.

Null Hypothesis 4. Of the 170 subjects who were candidates for selection for Null Hypotheses 4 and 5, 120 subjects were used with 50 subjects randomly selected out of the sample. Null Hypothesis 4 stated that no significant difference in overall mean scores on the Algebra I Word Problem Test existed among ninth-grade, first-year algebra students assigned to achievement levels of above-average, average, and below-average for computational mathematics. Forty subjects were assigned to all three achievement levels for computational mathematics. Each of the three achievement levels represented 33.33% of the total

sample. Table 10 reports this information.

Figure 1. Interaction of mean scores on the Algebra I Word Problem Test and achievement levels of above-average, average, and below-average for reading comprehension

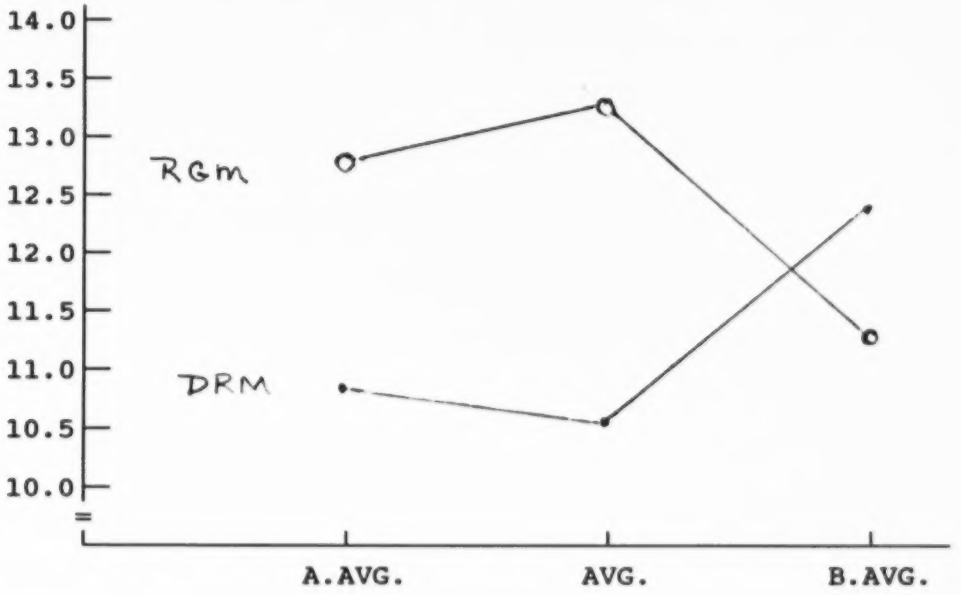


Table 10

Number and Percentage of Subjects Assigned to Achievement Level for Computational Mathematics for Evaluation of Null Hypothesis 4

Group	N	Percentage
Above-Average	40	33.33
Average	40	33.33
Below-average	40	33.34
Total	120	100.00

The 40 subjects assigned to the above-average achievement level for computational mathematics had a mean score of 13.07 and a standard deviation of 3.50 for problem-solving performance on the Algebra I Word Problem Test. The subjects in the average level had a mean score of 12.37 with a standard deviation of 3.74, while those in the below-average level had a mean score of 10.57 and a standard deviation of 2.74 on the AWPT. The adjusted mean score for the above-average achievement level was recorded as 12.41 with a standard deviation of 3.24; the average achievement level, as 12.46 with a standard deviation of 3.70; and the below-average level, as 11.15 with a standard deviation of 2.53. These results are reported in Table 11.

Table 11

Means, Standard Deviations, Adjusted Means, and Adjusted Standard Deviations for Subjects Grouped by Achievement Level for Computational Mathematics Ability

Group	N	X	SD	X'	SD'
Achievement Levels					
Above-average	40	13.07	3.50	12.41	3.24
Average	40	12.37	3.74	12.46	3.70
Below-average	40	10.57	2.74	11.15	2.53

A two-way analysis of covariance with an F' test evaluated the significance of variance of the row main-effects among the three achievement levels--above=average, average, and below-average--for computational mathematics ability upon students' problem-solving performance of first-year algebra word problems. In Table 12 the between groups adjusted sum of squares and adjusted mean square with 2 degrees of freedom for achievement levels for computational mathematics ability as 44.45 and 22.23, respectively. The adjusted error sum of squares was 1045.50 with an adjusted mean square of 9.25 and 113 degrees of freedom. The total adjusted sum of squares was 1238.5 with aa8 degrees of freedom. The calculated F' value was 2.40. Thje critical value to find significance at the 0.05 level with 2/113 df was 3.07.

Null Hypothesis 4 failed to be rejected. A significant difference did not exist among ninth-grade, first-year algebra students assigned to achievement levels of above-average, average, and below-average for computational mathematics ability.

Table 12

Summary of Analysis of Covariance of Comparing Adjusted Means for the Above-average, Average, and Below-average Achievement Levels for Computational Mathematics Using Mathematical Reasoning as a Covariant; and Comparing Adjusted Means for the Interaction of Achievement Levels and Treatments

Source	df	SS'	MS	F'	p
Treatments (DRM & RGM)	1	144.89	144.89	15.66	0.0002
Levels (Mathematical Reasoning Ability)	2	44.45	22.23	2.40*	0.0930
Interaction	2	3.73	1.86	0.20*	0.8183
Error	113	1045.50	9.25		
Total	118	1238.50			

*F' required for significance with 2/113 df is 3.07

Null Hypothesis 5. Null Hypothesis 5 stated that no significant interaction in the overall mean scores on the Algebra I Word Problem Test existed between ninth-grade, first-year algebra students taught reading comprehension skills in a content

area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-average, average, and below-average for computational mathematics.

Null Hypothesis 5 evaluated the interaction of two methods of teaching reading comprehension skills--DRM and RGM--in a content area and three achievement levels--above-average, average, and below-average--for computational mathematics ability upon students' problem-solving performance on the AWPT, using two-way analysis of covariance with mathematical reasoning as a covariant.

One hundred seventy subjects were candidates for selection for analysis in Null Hypothesis 5. Twenty-seven subjects or 15.88% were assigned to the above-average achievement level for computational mathematics ability for Treatment Group 1 (DRM). Thirty-three subjects or 19.41% were assigned to average achievement level, while 23 subjects or 13.54% were assigned to the below-average achievement level for Treatment Group 1 (DRM). Four subjects or 2.35% were dropped from the study; their scores on the AWPT did not meet the criteria for assignment to any achievement level for computational mathematics. Twenty-five subjects or 14.71% were assigned to the above-average achievement level for Treatment Group 2 (RGM). Twenty-one subjects or 12.35% were assigned to the average achievement level, while 33 subjects or 19.41% were assigned to the below-average achievement level.

Four subjects were dropped from Treatment Group 2 (RGM) because their scores did not meet the criteria for placement in any of the three achievement levels. These data are reported in Table 13.

Table 13

Number and Percentage of Subjects Grouped According to Treatment and Achievement Level for Computational Mathematics for Null Hypothesis 5 Prior to Random Selection

Group	N	Percentage
Treatment 1 (DRM)		
Above-average	27	15.88
Average	33	19.41
Below-average	23	13.54
Dropped	4	2.35
Treatment 2 (RGM)		
Above-average	25	14.71
Average	21	12.35
Below-average	33	19.41
Dropped	4	2.35
Total	170	100.00

After dropping 8 subjects who did not meet the criteria for assignment to an achievement level and randomly selecting out 42 subjects, 120 subjects were utilized in evaluating Null Hypothesis 5. Twenty subjects or 16.67% of the sample were assigned to each of the following groups: (a) above-average Treatment Group 1 (DRM); (b) average Treatment Group 1 (DRM); (c) below-average Treatment Group 1 (DRM); (d) above-average Treatment Group 2 (RGM); (e) average Treatment Group 2 (RGM); and (f) below-average Treatment Group 2 (RGM). These data are reported in Table 14.

Table 14

Number and Percentage of Subjects Selected for Evaluation of Null Hypothesis 5

Group	N	Percentage
Treatment 1 (DRM)		
Above-average	20	16.66
Average	20	16.66
Below-average	20	16.67
Treatment 2 (RGM)		
Above-average	20	16.67
Average	20	16.67
Below-average	20	16.67
Total	120	100.00

Above-average Treatment Group 1 (DRM) had a mean score of 11.80 with a standard deviation of 2.86. The average Treatment Group 1 had a mean score of 11.35 with a standard deviation of 3.84, while the below-average Treatment Group 1 had a mean score of 9.80 with a standard deviation of 2.51. The above-average Treatment Group 2 (RGM) had a mean score of 14.35 with a standard deviation of 3.69; the average Treatment Group 2 had a mean score of 13.40 with a standard deviation of 3.42; and the below-average Treatment Group 2 had a mean score of 11.35 with a standard deviation of 2.83. The total mean score was 12.01 with a standard deviation of 3.49. The adjusted mean score of the above-average Treatment Group 1 (DRM) was 11.10 with a standard deviation of 2.45. The average Treatment Group 1 had a mean score of 11.36 with a standard deviation of 3.96, while the below-average Treatment Group 1 had a mean score of 10.27 with a standard deviation of 2.29. The adjusted mean score of the above-average Treatment Group 2 was 13.72 with an adjusted standard deviation of 3.46, while the adjusted mean score of the average Treatment Group 2 was 13.57 with a standard deviation of 3.14. The below-average Treatment Group 2 had an adjusted mean score of 12.03 and an adjusted standard deviation of 2.49. The total adjusted mean score was 12.01 with a standard deviation of 3.25. These statistics are reported in Table 15.

Table 15

Means, Standard Deviations, Adjusted Means, and Adjusted Standard Deviations for Subjects Grouped by Treatment and Achievement Level for Computational Mathematics Ability

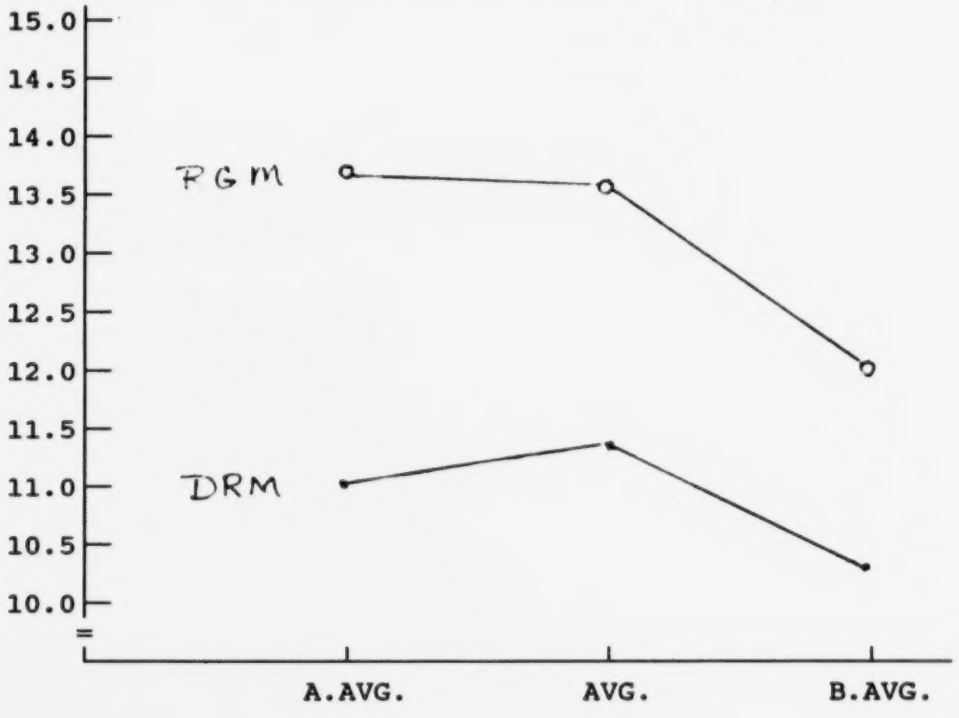
Group	N	X	SD	X'	SD'
Treatment 1 (DRM)					
Above-average	20	11.80	2.86	11.10	2.45
Average	20	11.35	3.84	11.36	3.96
Below-average	20	9.80	2.51	10.27	2.29
Treatment 2 (RGM)					
Above-average	20	14.35	3.69	13.72	3.46
Average	20	13.40	3.42	13.57	3.14
Below-average	20	11.35	2.83	12.03	2.49
Total	120	12.01	3.49	12.01	3.25

A summary of the two-way analysis of covariance comparing adjusted mean scores of the six groups is reported in Table 12 (page 32). The adjusted interaction sum of squares and adjusted interaction mean square with 2 degrees of freedom were 3.73 and 1.86, respectively. The total adjusted sum of squares was 1238.50 with 118 degrees of freedom.

The adjusted F' value was calculated as 0.20. The critical value at the 0.05 level of significance for 2/113 degrees of freedom is 3.07. Null Hypothesis 5 was accepted. No significant

interaction in overall mean scores on the AWPT existed between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-average, average, and below-average for computational mathematics. To better interpret the results from Table 12, a graphical presentation of the interactive effects is shown in Figure 2.

Figure 2. Interaction of mean scores on the Algebra I Word Test and achievement levels of above-average, average, and below-average for computational mathematics



Null Hypothesis 6. Of the 170 subjects who were eligible for selection for the analysis of Null Hypotheses 6 and 7, 120 were used with 50 subjects randomly selected out of the sample. Null Hypothesis 6 stated that no significant difference in overall mean scores on the Algebra I Word Problem Test existed among ninth-grade, first-year algebra students when assigned to achievement levels of above-average, average, and below-average for mathematical reasoning. Forty subjects were assigned to each of the three achievement levels for mathematical reasoning. Each level represented 33.3% of the sample. Table 16 reports this information.

Table 16

Number and Percentage of Subjects Assigned to Achievement Level for Mathematical Reasoning for Evaluation of Null Hypothesis 6

Group	N	Percentage
Above-average	40	33.3
Average	40	33.3
Below-average	40	33.4
Total	120	100.0

The 40 subjects in the above-average achievement level for mathematical reasoning had a mean score of 13.67 with a standard deviation of 3.76 for problem-solving performance on the

Algebra I Word Problem Test. The 40 subjects in the average achievement level had a mean score of 11.60 with a standard deviation of 2.91, while the 40 subjects assigned to the below-average achievement level had a mean score of 10.47 with a standard deviation of 3.45. The adjusted mean scores for the above-average, average, and below-average achievement levels for mathematical reasoning were 13.34, 11.66, and 10.75, respectively; the standard deviations for these achievement levels were reported as 3.58, 3.06, and 3.39, respectively. These statistics are reported in Table 17.

Table 17

Means, Standard Deviations, Adjusted Means, and Adjusted Standard Deviations for Subjects Grouped by Achievement Levels for Mathematical Reasoning Ability

Group	N	$\bar{X}$	SD	$\bar{X}'$	SD'
Achievement Levels					
Above-average	40	13.67	3.76	13.34	3.58
Average	40	11.60	2.91	11.66	3.06
Below-average	40	10.47	3.45	10.75	3.39

A two-way analysis of covariance with an F' test evaluated the significance of variance of the row main-effects among the three achievement levels--above-average, average, and below-average--for mathematical reasoning upon students' problem-

solving performance of first-year algebra word problems. Table 18 reports the between groups adjusted sum of squares and adjusted mean square with 2 degrees of freedom for achievement levels for mathematical reasoning as 137.58 and 68.79, respectively. The adjusted error sum of squares was 1247.90 with an adjusted mean square of 11.04 with 113 degrees of freedom. The calculated F' value was 6.23 and was significant at the 0.0029 level. The critical F' value to find significance at the 0.05 level with 2/113 df was 3.07.

Table 18

Summary of Analysis of Covariance of Comparing Adjusted Means for the Above-average, Average, and Below-average Achievement Levels for Mathematical Reasoning Using Computational Mathematics as a Covariant; and Comparing Adjusted Means for the interaction of Achievement Levels and Treatments

Source	df	SS'	MS	F'	p
Treatments (DRM & RGM)	1	42.60	42.600	3.86	0.0492
Levels (Meathematical Reasoning Ability)	1	137.58	68.792	6.23	0.0029
Interaction	2	24.80	12.401	1.12	0.3295
Error	113	1247.90	11.044		
Total	118	1452.90			

Null Hypothesis 6 was rejected. To determine which achievement levels for mathematical reasoning were significantly different, the adjusted means of the three achievement levels were compared using the Scheffe' test. The computed F' value for comparing the adjusted means for the above-average and average achievement levels was 2.56; for comparing the adjusted means for the above-average and below-average achievement levels was 6.07; and for comparing the adjusted means for the average and below-average achievement levels was 0.75. The critical F' value to find significance at the 0.05 level with 2/113 df was 3.07. A significant different exists in problem-solving performance of algebra word problems between the ninth-grade, first-year algebra students assigned to the above-average and below-average achievement levels for mathematical reasoning. Table 19 reports the results of this multiple comparison.

Table 19

Results of the Scheffe Test for Main Effect of Achievement Levels for Mathematical Reasoning *

Achievement Levels	Above-Average	Average	Below-Average
	N = 40	N = 40	N = 40
Mean	13.34	11.66	10.75

*Significant difference exists between above-average and below average groups.

Null Hypothesis 7. Null Hypothesis 7 stated that no significant interaction in overall mean scores on the Algebra I Word Problem Test existed between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-average, average, and below-average for mathematical reasoning.

Null Hypothesis 7 evaluated the interaction between two methods of teaching reading comprehension skills--DRM and RGM--in a content area and three achievement levels--above-average, average, and below-average--for mathematical reasoning ability upon students' problem-solving performance on the AWPT, using the two-way analysis of covariance with computational mathematics ability as a covariant.

One hundred seventy subjects were candidates for selection for the analysis of Null Hypothesis 7. Thirty subjects or 17.6% were assigned to the above-average achievement level for mathematical reasoning for Treatment Group 1 (DRM). Twenty-eight subjects or 16.5% were assigned to the average Treatment Group 1, while 21 subjects were assigned to the below-average Treatment Group 1. Eight subjects or 4.7% of the subjects in Treatment Group 1 were dropped from the study; their scores did not meet the criteria for assignment to an achievement level. Twenty-nine subjects or 17.1% were assigned to the above-average Treatment

Group 2 (RGM). Twenty-five subjects or 14.7% were assigned to the average Treatment Group 2, while 24 subjects were assigned to the below-average Treatment Group 2. Five subjects or 2.9% of the subjects in Treatment Group 2 did not meet the criteria for assignment to an achievement level and were dropped from the study. This is reported in Table 20.

Table 20

Number and Percentage of Subjects Grouped According to Treatment and Achievement Level of Mathematical Reasoning for Null Hypothesis 7 Prior to Random Selection

Group	N	Percentage
Treatment 1 (DRM)		
Above-average	30	17.6
Average	28	16.5
Below-average	21	12.4
Dropped	8	4.7
Treatment 2 (RGM)		
Above-average	29	17.1
Average	25	14.7
Below-average	24	14.1
Dropped	5	2.9
Total	170	100.0

After dropping the 13 subjects that did not meet the criteria for assignment to an achievement level for mathematical reasoning ability and randomly selecting out 37 subjects, 120 subjects were used to evaluate Null Hypothesis 7. Twenty subjects or 16.67% of the sample were assigned to each of the following groups: (a) above-average Treatment Group 1 (DRM); (b) average Treatment Group 1 (DRM); (c) below-average Treatment Group 1 (DRM); (d) above-average Treatment Group 2 (RGM); (e) average Treatment Group 2 (RGM); and (f) below-average Treatment Group 2 (RGM). These data are reported in Table 21.

Table 21

Number and Percentage of Subjects Selected for Evaluation of Null Hypothesis 7

Group	N	Percentage
Treatment 1 (DRM)		
Above-average	20	16.66
Average	20	16.66
Below-average	20	16.67
Treatment 2 (RGM)		
Above-average	20	16.67
Average	20	16.67
Below-average	20	16.67
Total	120	100.00

The above-average Treatment Group 1 (DRM) had a mean score of 12.65 with a standard deviation of 4.04. The average Treatment Group 1 had a mean score of 10.90 with a standard deviation of 2.57, while the below-average Treatment Group 1 had a mean score of 10.55 with a standard deviation of 4.02. The above-average Treatment Group 2 (RGM) had a mean score of 14.70 with a standard deviation of 3.23. The average Treatment Group 2 had a mean score of 12.30 with a standard deviation of 3.11, while the below-average Treatment Group 2 had a mean score of 10.40 with a standard deviation of 2.87. The total mean score was 11.92 with a standard deviation of 3.62.

The adjusted mean score of the above-average Treatment Group 1 was 12.40 with an adjusted standard deviation of 4.06. The adjusted mean score of the average Treatment Group 1 was 10.77 with an adjusted standard deviation of 2.70, and the adjusted mean score of the below-average Treatment Group 1 was 10.80 with an adjusted standard deviation of 3.95. The adjusted mean scores of the above-average, average, and below-average achievement levels for Treatment Group 2 are 14.28, 12.55, and 10.71, respectively. The adjusted standard deviations of these achievement levels are 2.83, 3.20, and 2.84, respectively. The total adjusted mean score and adjusted standard deviation are 11.92 and 3.52, respectively. These statistics are reported in Table 22.

Table 22

Means, Standard Deviations, Adjusted Means, and Adjusted Standard Deviations for Subjects Grouped by Treatment and Achievement Level for Mathematical Reasoning Ability

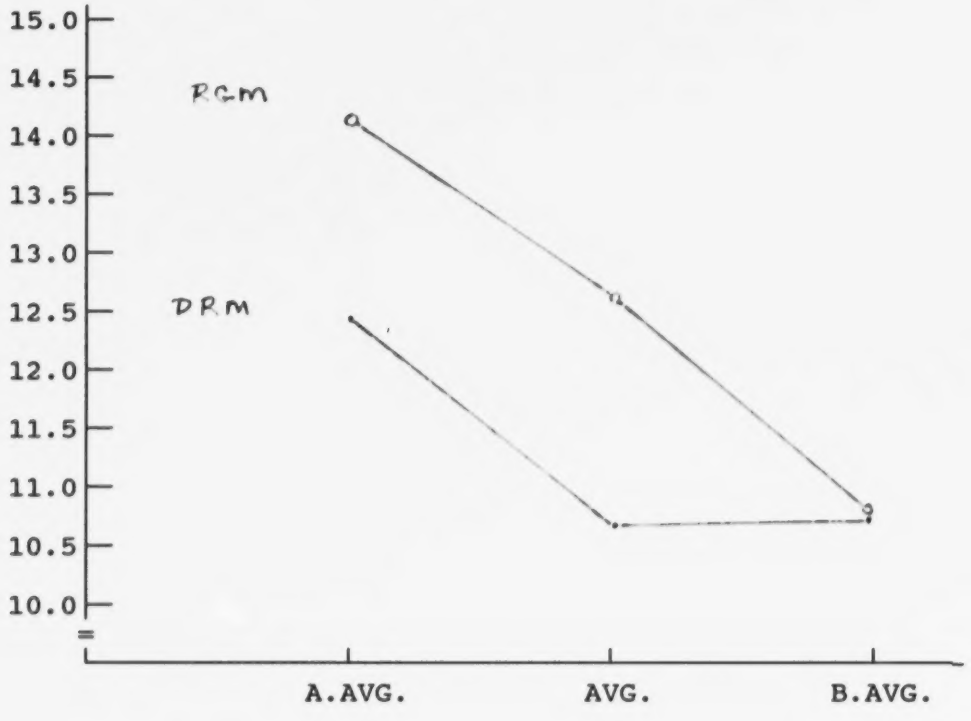
Group	N	$\bar{X}$	SD	$\bar{X}'$	SD'
Treatment 1 (DRM)					
Above-average	20	12.65	4.04	12.40	4.06
Average	20	10.90	2.57	10.77	2.70
Below-average	20	10.55	4.02	10.80	3.95
Treatment 2 (RGM)					
Above-average	20	14.70	3.23	147.28	2.83
Average	20	12.30	3.11	12.55	3.20
Below-average	20	10.40	2.87	10.71	2.84
Total	120	11.92	3.62	11.92	3.52

A summary of the two-way analysis of covariance comparing adjusted mean scores of the six groups is given in Table 18 (page 105). The adjusted interaction sum of squares and adjusted interaction mean square with 2 degrees of freedom are reported as 24.80 and 12.40, respectively. The total adjusted sum of squares was 1452.90 with 118 degrees of freedom.

The adjusted F' value was calculated as 1.12. The critical value at the 0.05 level of significance for 2/113 df was 3.07. Null Hypothesis 7 was accepted. No significant interaction in

overall mean scores on the AWPT existed between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method when assigned to achievement levels of above-average, average, and below-average for mathematical reasoning ability. A graphical presentation of the interactive effect is shown in Figure 3.

Figure 3. Interaction of mean scores on the Algebra I Word Test and achievement levels of above-average, average, and below-average for mathematical reasoning



Difference of Mean Gain Scores in Reading Comprehension Between Method of Teaching Reading

This hypothesis provided a determination of the overall mean gain scores of two groups taught reading comprehension skills in a content area--Directed Reading Method and Reading Guide Method--upon students' problem-solving performance of first-year algebra word problems.

Null Hypothesis 8. Null Hypothesis 8 stated that no significant difference in overall mean gain scores in reading comprehension achievement on the California Achievement Test, Form F, Reading Comprehension Subtest existed between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method. One hundred seventy subjects were used to evaluate Null Hypothesis 8. Of the one hundred seventy subjects 87 or 51.2% were taught reading comprehension skills in a content area using the Directed Reading Method, while 83 subjects or 48.8% were taught reading comprehension skills in a content area using the Reading Guide Method. Table 23 reports these findings.

Table 23

Number and Percentage of Subjects Assigned to Method of Reading for Evaluation of Null Hypothesis 8

Group	N	Percentage
Directed Reading Method	87	51.2
Reading Guide Method	83	48.8
Total	170	100.0

The pretest mean scores on the California Achievement Test, Form F, Reading Comprehension Subtest for Treatment Group 1 (DRM) and Treatment Group 2 (RGM) were 31.40 and 36.02, respectively. The posttest mean scores on the California Achievement Test, Form F Reading Comprehension Subtest were 39.14 and 41.04, respectively. Table 24 reports these statistics.

Table 24

Pretest and Posttest Mean Scores on CAT Reading Comprehension Subtest by Treatment Groups

Group	N	Pretest $\bar{X}$	Posttest $\bar{X}$
Treatment 1 (DRM)	87	31.40	39.14
Treatment 2 (RGM)	83	36.02	41.04
Total	170	33.66	40.06

A t-Test for independent samples was used in evaluating the mean gain scores of Treatment Group 1 and Treatment Group 2 on the California Achievement Test, Form F, Reading Comprehension Subtest. Treatment Group 1 (DRM) had a mean gain score of 7.736 with a standard deviation of 9.970. Treatment Group 2 (RGM) had a mean gain score of 5.012 with a standard deviation of 7.058. The computed t value was 2.06 with 2/155.2 df and was significant at the 0.0385 level. The critical value at the 0.05 level of significance was 1.645. Table 25 reports these statistics.

Table 25

t-Test for Independent Samples for Mean Gain Scores in Reading Comprehension for Groups Using the Directed Reading Method and the Reading Guide Method

Treatment Groups	$\bar{N}$	X	SD	t	p
Treatment 1 (DRM)	87	7.736	9.970	2.06	0.0385*
Treatment 2 (RGM)	83	5.012	7.058		

*p < 0.05 2/155.2 df

Null Hypothesis 8 was rejected. A significant difference in overall mean gain scores in reading comprehension achievement on the California Achievement Test, Form F, Reading Comprehension Subtest did exist between ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Directed Reading Method and ninth-grade, first-year algebra students taught reading comprehension skills in a content area using the Reading Guide Method. The students in Treatment Group 1 (Directed Reading Method) had a higher mean gain score on the CAT Reading Comprehension Subtest than those in Treatment Group 2 (Reading Guide Method).

Conclusions

The following conclusions were drawn from the analysis of the data gathered during this field experiment:

1. The algebra I problem-solving performance of ninth-grade students is improved by employing a method of teaching reading in the content area. Research has shown that reading guides with three levels, literal, applied, and interpretive, used in the content area have impacted students' comprehension in English (Shablak, 1972), in social studies (Berget, 1973), and in mathematics subjects of algebra (Riley, 1979) and trigonometry (Riley, 1976).

2. Ninth-grade algebra I students taught reading comprehension skills in a content area using the Reading Guide Method will outperform ninth-grade, algebra I students taught reading comprehension skills in a content area using the Directed

Reading Method in problem-solving performance. In a study by Riley (1979), in which four treatment groups received instruction by one of four reading methods--three methods of which were different types of reading guides while one method was directed reading--the findings indicated no statistically significant difference in problem solving ability of mathematics word problems by seventh grade students. However, two of the reading guide methods did produce significant gains in word problem comprehension.

3. The Reading Guide Method is most effective with ninth-grade algebra I students who are above-average and average in reading comprehension skills.

4. The Directed Reading Method is more effective with ninth-grade algebra I students who are below-average in reading comprehension skills.

5. The Reading Guide Method is more effective than the Directed Reading Method in improving algebra I students' problem-solving performance regardless of the students' computational mathematics ability.

6. The Reading Guide Method is more effective than the Directed Reading Method in improving algebra I students' problem-solving performance regardless of the students' mathematical reasoning ability.

7. In reading comprehension achievement ninth-grade, first-year algebra students taught reading comprehension skills in the content area of mathematics using the Directed Reading Method

will outperform ninth-grade, first-year algebra students taught reading comprehension skills using the Reading Guide Method.

Recommendations

The following recommendations were drawn from the results of this field experiment:

1. The Reading Guide Method of teaching reading comprehension skills in the content area to improve problem-solving performance of ninth-grade algebra I students is recommended.

2. Further research might address itself to applying the Directed Reading Method and the Reading Guide Method of teaching reading comprehension skills in a content area upon problem-solving performance to a larger number of word problems in the first-year algebra curriculum.

3. Researchers should investigate the effects of the Directed Reading Method and the Reading Guide Method upon problem-solving performance of algebra word problems over a longer period of time.

4. The results of this study, did not support prior research findings by Riley and Pachtman (1978), which had indicated that below-average students in reading comprehension skills performed more effectively using the Reading Guide Method rather than the Directed Reading Method. Further research is recommended for studying methods of reading instruction in a content area--reading guides and directed reading--that would

be appropriate for students with different levels of reading comprehension ability.

5. One criteria for ability-grouping algebra I classes should be reading comprehension achievement. The Reading Guide Method should be incorporated into classroom instruction when the reading comprehension achievement level of students is above-average or average. The Directed Reading Method should be an integral part of classroom instruction when students' reading comprehension achievement level is below-average.

6. The Directed Reading Method of teaching reading comprehension skills in the content area of mathematics to improve reading comprehension ability is recommended.

7. Mathematics teachers need to update their classroom instruction by incorporating a reading method in a content area into their teaching of mathematics. Teachers who have not taken a course in reading in the content area should be required to do so.

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Appendix A

Review of Related Literature

International and national studies have reported that the mathematical performance of students in the United States was well below that of students in countries competitive with the United States in business, science, and technology (Campbell & Fey, 1988). Declining scores on college entrance examinations in mathematical achievement, particularly in problem-solving and higher-order thinking skills, gained the attention of the mathematics community. The National Council of Teachers of Mathematics recommended in their 1980 publication, An Agenda for Action, that "Problem solving must be the focus of school mathematics in the 1980's" (Campbell & Fey, 1988). To support this position problem solving was listed as the first curriculum standard for levels K-4, 5-8, and 9-12 in NCTM's (1989) Curriculum and Evaluation Standards for School Mathematics. The National Council of Supervisors of Mathematics in support of NCTM's views of mathematics education included problem solving in the position statement as one of twelve components of essential mathematics (Stiff, 1989). Problem solving is an essential aspect in solving word problems. The need for proficiency in problem solving skills and students' continued difficulty in solving word problems has claimed attention from educators and researchers (Berger, 1984). In algebra, the first mathematics course in which concepts are more subtle and abstract than the simpler arithmetic manipulations of prior mathematics

courses (Gerace & Mestre, 1982), students found that higher cognitive processes involving decisions on "how to use knowledge and skills . . . to interpret problems and generate answers" (Doyle, 1988, p. 170) are imperative. Research findings have correlated computational mathematics ability, mathematical reasoning ability, and reading comprehension skills with success in solving algebra word problems (Call & Wiggins, 1966; Mars, 1970; Derry & Kellis, 1986; Gagne, 1983; Jansson, 1986).

An experimental study by Call and Wiggins (1966) showed a correlation between students' ability to solve second year algebra word problems and the presence of special reading instruction. The experimental group outperformed the control group; the results indicated the need for implementing the teaching of special reading skills for solving mathematical problems.

In a study conducted by Mars (1970) involving 382 subjects the correlation coefficient that was obtained indicated that reading comprehension and general intelligence were highly related to geometry achievement. Other variables in the study which did not exhibit high coefficients of correlation were reading vocabulary, total reading achievement, and arithmetic achievement. The review of related literature was compiled for the purpose of examining current empirical studies relative to solving word problems in first-year algebra. For organizational clarity, the following sections were used: (a) problem solving ;

(b) methods of instruction and reading comprehension; and (c) summary.

Problem Solving

> Problem solving as defined by Good (1959) is a process employed by all people at all levels of maturity of discovering or educing new relationships among things observed or sensed; the process includes conscious or subconscious assumption, or hypothesis, of a possible relationship within a simple or complex system of thought and understanding, and means to test through experience the acceptability of the assumption. (p. 439)

Page and Thomas (1977) described problem solving as a "term in Gagne's theory of learning which represents the highest category of intellectual skill. The characteristic of problem-solving is the combination of two or more rules in a novel way in order to solve a problem" (p. 273). A key factor in "problem-solving is the application of past experience to arrive at a solution not previously known to the person" (Deighton, 1971, p. 219).

According to An Agenda for Action (1980), "problem solving involves applying mathematics to the real world, serving the theory and practice of current and emerging sciences, and resolving issues that extend the frontiers of the mathematical sciences themselves" (p. 2). True problem solvers possess

technical and practical skills necessary to resolve problematic situations and the ability to comprehend relationships and utilize fundamental principles (An Agenda for Action, 1980).

Lester (1980) cited four types of factors associated with mathematical problem solving. These factors are as follows: (a) task variables (the problem itself); (b) subject variables (characteristics of the individual); (c) process variables (problem-solving behavior); and (d) instruction variables (environmental features). Task variables are such problem-related factors as problem format and problem structure. Subject variables include the following characteristics, conceptual style, previous mathematical background, reaction under stress and field independence. Process variables, which are closely tied with task and subject variables, relate to the individual's problem solving behavior. These behaviors involve the organization and processing of information, the types of cognitive strategies for use in attacking a problem, and the methods used to evaluate problem-solving procedures. Instructional variables, which are external to the problem and the problem solver, are methods or skills to assist individuals in becoming better problem solvers (Lester, 1980). In education problem solving has been addressed from two different viewpoints: theories of instruction and theories of cognition. In the last decade, researchers who focused on teaching have examined: (a) the thinking and decision making of teachers and students before, during, and after classroom instruction; (b) students'

perceptions of teachers' behavior and intent; (c) students' perceptions of the classroom task; and (d) students' reports of their attention, understanding, and the use of cognitive strategies for learning from instruction (Carpenter & Peterson, 1988).

These researchers generally have not taken into account the nature of the subject matter being taught; and therefore,

> . . . have not directly investigated the problem of how children learn mathematics, nor addressed questions regarding the knowledge base that students bring to instruction, how this knowledge influences what and how students learn, and how the knowledge changes as a result of instruction. (Carpenter & Peterson, 1988; p.80)

The steps in problem-solving in most theories are: (a) phase of encoding--internal representation; (b) conception or representation of the problem; (c) solution of the problem; and (d) evaluation (Meijer, 1986). The review of related literature indicated that empirical studies addressed one or more of these problem-solving steps. Studies by Meijer (1986), Muth (1986), Derry & Kellis (1986), Mayer (1981), Hamilton (1986), and Ballew (1982) indicated that factors necessary for the encoding phase of the problem-solving process includes linguistic and semantic knowledge, as well as, general and domain-specific knowledge. The conception or representation phase of the problem-solving

process requires students' ability to translate from the English language into the mathematical language of numbers and symbols (Derry, 1986; Muth, 1986; Mayer, 1981; Hamilton, 1986; Meijer, 1986; Jansson, 1986; Ballew, 1982; Clement, 1981; Mestre, 1986; Rosnick, 1980, p. 3; Gagne, 1983), to distinguish between relevant and irrelevant facts (Derry, 1986; Hamilton, 1986; Muth, 1986; Mayer, 1981), and to choose an appropriate strategy or schema (Derry, 1986; Dauda, 1986; Fernandez, 1986; Galbraith, 1986; Ghunaym, 1986; Mathison, 1986; Dean, 1986). The solution phase of the problem-solving process requires computational skills (Ballew, 1982; Glennon & Callahan, 1968; Muth, 1986; Sowder, 1986; Carpenter, Moser, & Romberg, 1982). Derry's study (1986) indicated that the evaluation phase of the problem-solving process is the validation of answers. In Sowder's study (1986), however, validation of the correct operation for solving the word problem was addressed by 167 sixth graders solving twelve word problems.

Derry (1986) analyzed and compared thought processes verbalized by low-ability soldiers and high-ability college students while solving arithmetic word problems. Low-ability soldiers spent 24.3% of their time reading and rereading a problem while college students used only 9% for reading and 41.39% restructuring problem statements and focusing on important ideas. These findings suggested the importance of text translation skills unique to word problems. The summary findings implicated translation and representation factors associated with

focusing on pertinent aspects of a problem statement. The soldiers missed the goal statement, ignored relevant facts, mislabeled subgoal calculations, lacked use of paper and pencil, and did not check answers. These results initiated the formulation of a general model called the Four C's. The Four C's model was tested on two Army posts. The treatment group performed significantly better than the control group on the near-transfer portion of the posttest and on the subordinate processing skills.

The review of related literature indicated that other factors influencing problem-solving performance in mathematics were student's general intelligence (Mars, 1970; Span & Overtoom-Corsmsit, 1986), sex (Aiken, 1987; Lovett, 1969), prognosis test results (Hanna, 1974), development of mathematical cognition (Kaye, 19; Ashcraft, 1983; Hiebert & Wearne, 1985), type of word problem, (Caldwell & Goldin, 1987; Dauda, 1986), and methods of instruction (Fernandez, 1986; Call & Wiggins, 1966; Ghunaym, 1986; Thaeler, 1986; Maffei, 1973; Riley, 1979; Tenebaum, 1986; Johnson, H.C., 1944).

Methods of Instruction

Researchers have moved a step closer to understanding children's learning from mathematics instruction, yet much work remains. Areas for exploration, according to Carpenter and Peterson (1988), include the nature of transitions or knowledge during instruction; application of "research on individual

children or small groups of children in controlled experimental conditions to instruction in classrooms of 25 to 30 students"; and prescriptions for instruction (p.84). New directions in educational research concentrate on ". . . the alterability of educational methods and educational outcomes" (Tenebaum, 1986, p. 113). The quality of instruction is regarded as a vital, alterable variable which affects cognitive outcomes of learning and may also alter the relationship between prior and final cognition of students (Tenebaum, 1986). Methods of instruction used in mathematics classrooms were developed by two disciplines of scientific knowledge--research on teaching and research on children's thinking (Carpenter & Peterson, 1988). Although both ". . . approach the problem of learning mathematics from instruction from different perspectives" (Carpenter & Peterson, 1988), they advocated that subject matter and goals of instruction must be primary values in the study of learning from instruction.

Several instructional methods from the cognitive domain were presented in the review of literature. Researchers exploring children's cognition focused upon what is learned and did not address the question of how learning occurs. Malena (1987) cited comprehension by the learner as the critical element in learning. He further stated that comprehension involves thinking while metacognition is thinking about learning. In teaching cognitive skills an exercise is divided into four steps: (1) demonstration on how to perform the skill; (2) session for guided practice; (3) session for independent practice; and (4) periods of feedback

before, during, and after each step (Malena, 1987). For teaching metacognitive skills, textbook reading assignments are divided into prereading, reading, and postreading assignments. During each phase of the reading assignment students ask themselves these three questions: (1) what, (2) why, and (3) how, while self-monitoring their progress (Malena, 1987).

Another cognitive approach, the learning cycle method, implemented by Stepans (1984), effectively teaches abstract mathematical concepts to all students, including those not yet having acquired the formal level of thought. The four-phase learning cycle method includes introduction, exploration, concept invention, and application. The introductory is a question, problem, or challenging situation. The exploration phase encourages learning with minimal guidance, and the concept-invention phase incorporates into concepts student-generated ideas aided by teacher direction. In the application phase students exercise use of newly acquired skills or concepts (Stepans, 1984).

Tenebaum (1986) conducted two studies in two different content areas and two grade levels in which three different group instructional conditions were applied: (1) enhanced cues, participation, reinforcement, and feedback-corrective procedure (CPR + FB/C); (2) conventional instruction; and (3) mastery learning (ML). The findings indicated that the CPR + FB/C group instruction, which attained 85% mastery criterion on lower mental processes (LMP) and 69% on higher mental processes (HMP), outperformed the conventional instruction group and the

mastery learning group. These results verify that when favorable conditions are given to students their performance on HMP is more strongly affected. By improving the quality of instruction, that is, using cues, participation, and feedback, students attain both higher and lower mental processes (Tenebaum, 1986).

Hiebert and Wearne (1988) suggested ". . . a cognitive instructional approach tailored to address the learning of complex school tasks in classroomlike settings" (p. 106). Components of this proposed methodology are: (1) selection of well-defined content domain; (2) identification of cognitive processes that are keys to successful performance in the domain; (3) identification of an instructional sequence that promotes the use of the key cognitive processes; and (4) evaluation of instruction. The selection of content determines the set of cognitive processes observed and inferred. The cognitive processes must be specific to the solving of the subject-matter task. Essential features of instruction must be limited in scope, clearly focused, and specifiable. The two kinds of tasks that measure cognitive change are direct measures which access students' performance in content domain and transfer tasks which indicate learning at a deep and enduring level and measures flexibility and robustness of target processes. Hiebert and Wearne (1988) summarized their methodology by stating: "The importance of looking at underlying cognitive processes when investigating the effects of instruction on learning is demonstrated in three ways" (p. 107). These three ways are as follows: (1) Changes in performance are more directly traced to

instructional events by inserting descriptions or process change between two events; (2) Students' prior knowledge is assessed as an influence upon effects of instructional interference of instruction; and (3) Direct study of deeper-level issues in learning and instruction is permissible. "By focusing on the processes students use, how the processes change, and how process changes produce performance changes, it is possible to examine directly relationships between understanding and performance" (Hiebert & Wearne, 1988, p. 107).

Researchers studying teaching have focused upon the problems of classroom instruction and upon the improvement of instruction in schools with little of no concern for what is taught. The findings from a study by Hembree (1987) regarding word-problem format in solving algebra word problems showed significant gains by students when correctly drawn pictures were used in studying and testing and when data was placed in the order needed for writing equations. Thaeler (1986) proposed a nine-step method for solving algebra word problems. The format consisted of: (1) drawing a sketch to get a mental picture; (2) listing all numerical quantities in the problem, both explicit and implicit; (3) choosing something that each side of an equation can name; (4) elaborating on the same-same approach; (5) substituting values and variables into the equation; (6) solving the equation; (7) using additional calculations to answer the original problem; (8) checking; and (9) trying alternative solutions.

In a study conducted by Fernandez (1986) two instructional

strategies on solving algebra word problems were utilized by remedial college students. The two instructional strategies were the direct translation method, using diagrams, and the schema method. The study used a randomized block design with reading as the blocking variable. The 120 subjects were enrolled in a basic algebra course at the University of Turabo in Puerto Rico. The study concluded that both strategies improved algebra word problem solving of remedial mathematics college students. As implications of the study, instructors should use either method when teaching remedial mathematics college students and when teaching students to read mathematics.

Reading research and pedagogical literature indicated that mathematics should be read in the same manner as other textbooks, using the SQ3R method--Survey, question, Read, Reflect, Review--or the PGR method--Program Guided Reading Johnson, L.L., 1984). The PGR approach emphasizes comprehension while utilizing reading to assist in the construction of a heuristic of the problem. Another method advocated for use in teaching algebra word problems is the PQ4R method developed by Thomas and Robinson, both reading specialists (Maffei, 1973). The following PQ4R steps are listed as: (1) Preview--list unknown words and assign a meaning to them; (2) Question--write the direct question of the problem; (3) Read--list all words and facts in a logical order; (4) Reflect--translate word facts into algebraic facts using a variable; (5) Rewrite--write step 4 as a balanced equation and then proceed to solve; and (6) Review--check to see if the solution is logical (Maffei, 1973). A study demonstrated that

the teaching of word problems is basically an implementation of reading skills rather than mathematical skills. In the study an English teacher instructed a mathematics class, the experimental group, in reading comprehension skills relative to word problems while the control group received regular mathematics instruction by a mathematics teacher. A variation of the SQ3R study skill device was used by the experimental group. The results of the study indicated that students receiving reading skill instruction by the English teacher outperformed students in a regular mathematics class. Recommendations from the study suggested the incorporation of reading skills and grammar for significant increase in performance of mathematics word problems (Maffei, 1973).

Other recommended reading methods for solving algebra word problems were the Directed Reading Method and Reading Guide Method (Riley & Pachtman, 1978). The Directed Reading Method consists of these five steps: (1) read the problem slowly; (2) reread to determine what is asked; (3) decide facts of the problem ; (4) decide the process to be used; and (5) estimate and then compute the answer (Riley & Pachtman, 1978). The Directed Reading Method assumes that students can understand and apply appropriate concepts while the Reading Guide Method does not make that assumption.

The Reading Guide Method provides alternatives, thereby fostering in students a perception of reading and problem solving as a process rather than a series of unrelated steps. A reading guide is a set of statements that are read and responded to by

the reader (Riley & Pachtman, 1978). A reading guide based on a three-level construct of comprehension is

> designed to guide students' understanding at the literal level of comprehension (what is actually stated), the interpretive level (what is meant), and the applied level (a combination of literal and interpretive levels and any previous knowledge or experience brought to the task). (Riley & Pachtman, 1978, p. 531)

Research has shown that reading guides with three levels--literal, applied, and interpretive--used in a content area have impacted students' comprehension in English (Shablak, 1972), in social studies (Berget, 1973) and in the mathematics subjects of algebra (Riley, 1979) and trigonometry (Riley, 1974). A study by Riley (1974) investigated the effects of ". . . three level reading guides and small group discussion upon eleventh grader's ability to solve trigonometry problems" (p. 116). Each of the two treatment groups used different types of reading guides. The two types of reading guides were: the literal, interpretive, applied levels (LIA) and the literal, applied, interpretive levels (LAI). Both treatment groups had significant gains in problem solving ability relative to the trigonometry problems. The study showed no statistically significant difference in ability to solve trigonometry problems by either group. At the $p < .15$ level of significance a trend favored the LAI group. The research suggested ". . . that reading instruction can improve

understanding of mathematics . . . and that . . . reading guides might be a viable method of bringing about such improvement (Riley, 1974, p. 117).

The purpose of a second study by Riley (1979) ". . . was to determine if varying the sequence and content of three level guides for reading word problems in algebra affects students' comprehension of word problems" (p. 113). Each of the three groups used in the study received one of the three types of reading guides--literal, applied, interpretive (LAI); literal, interpretive, applied (LIA); and literal, applied (LA). The subjects for the study consisted of 74 ninth grade algebra students of average ability who attended a middle-class suburban high school. The design for the study was a modification of nonequivalent control group with intact groups. The students independently completed their study guide for each of the eight word problems, then utilized small groups for discussion of results. Teachers monitored the small groups and then followed up with a large group discussion. Eight guides were presented over a period of three weeks. The results indicated that significant gains in literal level comprehension occurred with the LA guides, while the LIA guides had a negative effect on literal level comprehension. The LA group was also more effective than the LIA or LAI groups in improving literal level comprehension. For both gains and effectiveness, the LAI was superior to the LIA guide. No significant improvement in interpretive level of comprehension of mathematical concepts occurred in any of the treatment groups. The LIA guides were

superior to LAI in improvement of applied level comprehension. The study suggested that further research should be conducted to determine if reading guides are more effective than the directed reading method in improving word problem comprehension (Riley, 1979).

A third study by Riley (1979) ". . . compared the effects of reading guides and a directed reading method on students' comprehension of word problems, problem solving ability, and attitude toward mathematics" (p.79). Three hundred seventy-four seventh grade students from a middle to upper middle class suburban junior high school were randomly assigned to one of the four treatment groups--LAI, LIA, LA and Directed Reading Method (DRM). Reading guides and DRM worksheets were written for ten word problems. Students worked independently on the reading guides or worksheets and then compared and discussed answers in small groups. Large group discussion led by the teacher followed small group discussion. The results of the study indicated that significant gains were produced by the LAI and LIA reading guides. No significant difference in comprehension of word problems was found among the four treatment groups. No treatment was superior in stimulating comprehension. No statistically significant difference in problem solving ability of the four treatment groups and no significant gain in problem solving ability of the four treatment groups was established. The researcher suggested that further research in applying the LAI, LIA, LA reading guides and the DRM to: (1) larger numbers of word problems in the existing curriculum; (2) treatment groups

over an extended period of time; and (3) subjects in a variety of modes (Riley, 1979).

Summary

Problem solving is a process of reasoning which leads to finding the correct solution to a problem situation. Research findings have correlated computational mathematics ability, mathematical reasoning ability, reading comprehension skills, and general intelligence with success in solving algebra word problems. Lester (1980) cited four types of factors associated with problem solving as task variables, subject variables, process variables, and instruction variables. Problem solving has been approached from two different viewpoints: theories of instruction and theories of cognition. In most theories the steps in problem-solving processes are similar. These steps are: (1) phase of encoding; (2) conception or representation of the problem; (3) solution of the problem; and (4) evaluation. The review of related literature indicated that empirical studies have addressed one or more of these problem-solving steps.

The review of related literature also indicated that several instructional methods from the cognitive domain have been investigated to determine their effectiveness in problem solving. Such studies have included metacognition by Malena (1987), the learning cycle method by Stepans (1984), the CPR + FB/C group instruction by Tenebaum, and others.

Reading research and pedagogical literature have indicated that mathematics should be read in the same manner as other

textbooks. Several reading methods have been modified for use in solving mathematics word problems. The literature cited such reading methods as the SQ3R method, PGR method, the PQ4R method, the Reading Guide method and the Directed Reading method. Empirical studies have indicated that reading guides with three levels, literal, applied, and interpretive, have impacted students' comprehension, not only in solving algebra word problems, but also in trigonometry, English, and social studies. Problem solving training using a reading method does improve problem solving ability in a content area.